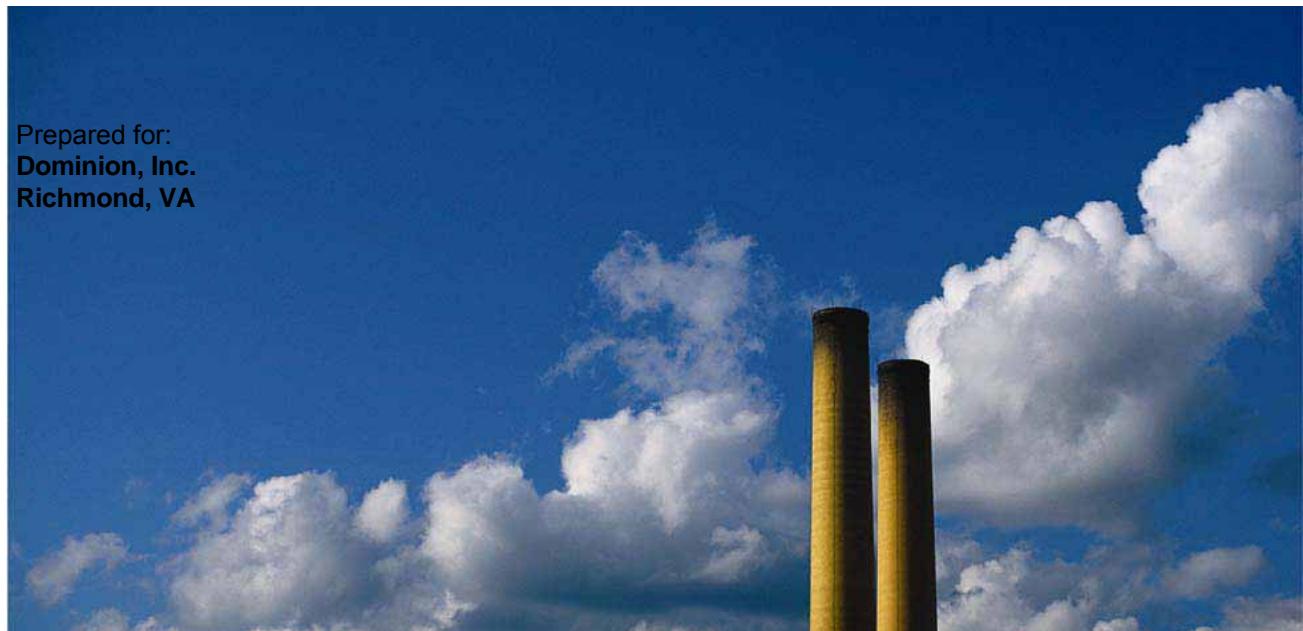


Prepared for:  
Dominion, Inc.  
Richmond, VA



# Best Available Retrofit Technology (BART) Exemption Modeling Analysis – Possum Point Power Station Unit 5

ENSR Corporation  
August 2006  
**Document No.: 02285-027-100**

Prepared for:  
**Dominion, Inc.**  
Richmond, VA

# Best Available Retrofit Technology (BART) Exemption Modeling Analysis Possum Point Power Station Unit 5



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## Contents

<b>1.0 Introduction .....</b>	<b>1-1</b>
1.1 Objectives .....	1-1
1.2 Location of Source vs. Relevant Class I Areas .....	1-1
1.3 Organization of Report Document .....	1-1
<b>2.0 Source Description and Emissions Data.....</b>	<b>2-1</b>
2.1 Unit-Specific Source Data .....	2-1
<b>3.0 Input Data to the CALPUFF Model.....</b>	<b>3-1</b>
3.1 General Modeling Procedures .....	3-1
3.2 Air Quality Database (Background Ozone and Ammonia) .....	3-1
3.3 Natural Conditions and Monthly f(RH) at Class I Areas .....	3-1
<b>4.0 Air Quality Modeling Procedures .....</b>	<b>4-1</b>
4.1 Model Selection and Features .....	4-1
4.2 Modeling Domain and Receptors.....	4-1
4.3 Technical Options Used in the Modeling .....	4-1
4.4 Light Extinction and Haze Impact Calculations .....	4-1
<b>5.0 Presentation of Modeling Results .....</b>	<b>5-1</b>

## List of Appendices

Appendix A Basis for Source-Specific PM<sub>10</sub> Speciation and Sulfuric Acid Emissions for BART Baseline Case

Appendix B CALPOST List Files for Shenandoah, Dolly Sods, Otter Creek, James River Face, and Brigantine

## List of Tables

Table 2-1	Possum Point Modeling Emissions and Stack Parameters <sup>1</sup> .....	2-2
Table 4-1	Annual Average Background and Monthly f(RH) used in CALPOST.....	4-2
Table 5-1	Summary of Results – Possum Point Refined BART Exemption Modeling.....	5-1

## List of Figures

Figure 1-1	Location of Class I Areas in Relation to Possum Point.....	1-2
Figure 3-1	Extent of Computational Grid .....	3-3

## 1.0 Introduction

### 1.1 Objectives

The Regional Haze Rule requires Best Available Retrofit Technology (BART) for any BART-eligible source that "emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility" in any mandatory Class I federal area. Pursuant to federal regulations, states have the option of exempting a BART-eligible source from the BART requirements based on dispersion modeling demonstrating that the source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area. In addition, the Environmental Protection Agency (EPA) has promulgated a rule allowing states subject to the Clean Air Interstate Rule (CAIR) to determine that CAIR satisfies the BART requirements for SO<sub>2</sub> and NOx for electric generating units (EGUs). The Virginia Department of Environmental Quality (DEQ) has determined that CAIR satisfies the BART requirements for SO<sub>2</sub> and NOx for EGUs. Therefore, this modeling report focuses on performing the BART modeling analysis for particulate matter (PM) only. The final BART rule at 70 FR 39160 notes that PM<sub>10</sub> may be used as an indicator for PM in this step of the BART process and thus, PM<sub>10</sub> was used for the exemption modeling.

Unit 5 at Possum Point Power Station (Possum Point), located in Dumfries, VA, is owned and operated by Dominion and has been identified as a BART-eligible source. The modeling procedures outlined in this report were used to determine whether the source is subject to BART requirements. The modeling procedures are consistent with the protocol letter submitted to DEQ on April 13, 2006 along with those outlined in the updated final VISTAS common protocol (dated December 22, 2005, revision 3 – July 18, 2006). The VISTAS common protocol is available at [http://www.vistas-sesarm.org/BART/BARTModelingProtocol\\_rev3\\_18Jul2006.pdf](http://www.vistas-sesarm.org/BART/BARTModelingProtocol_rev3_18Jul2006.pdf).

The results of the refined CALPUFF modeling analysis demonstrates that PM<sub>10</sub> emissions from Possum Point Unit 5 do not cause or contribute to regional haze in any Class I area. Thus, Possum Point Unit 5 is not "subject to BART" and is exempt from further analysis under the BART rule.

### 1.2 Location of Source vs. Relevant Class I Areas

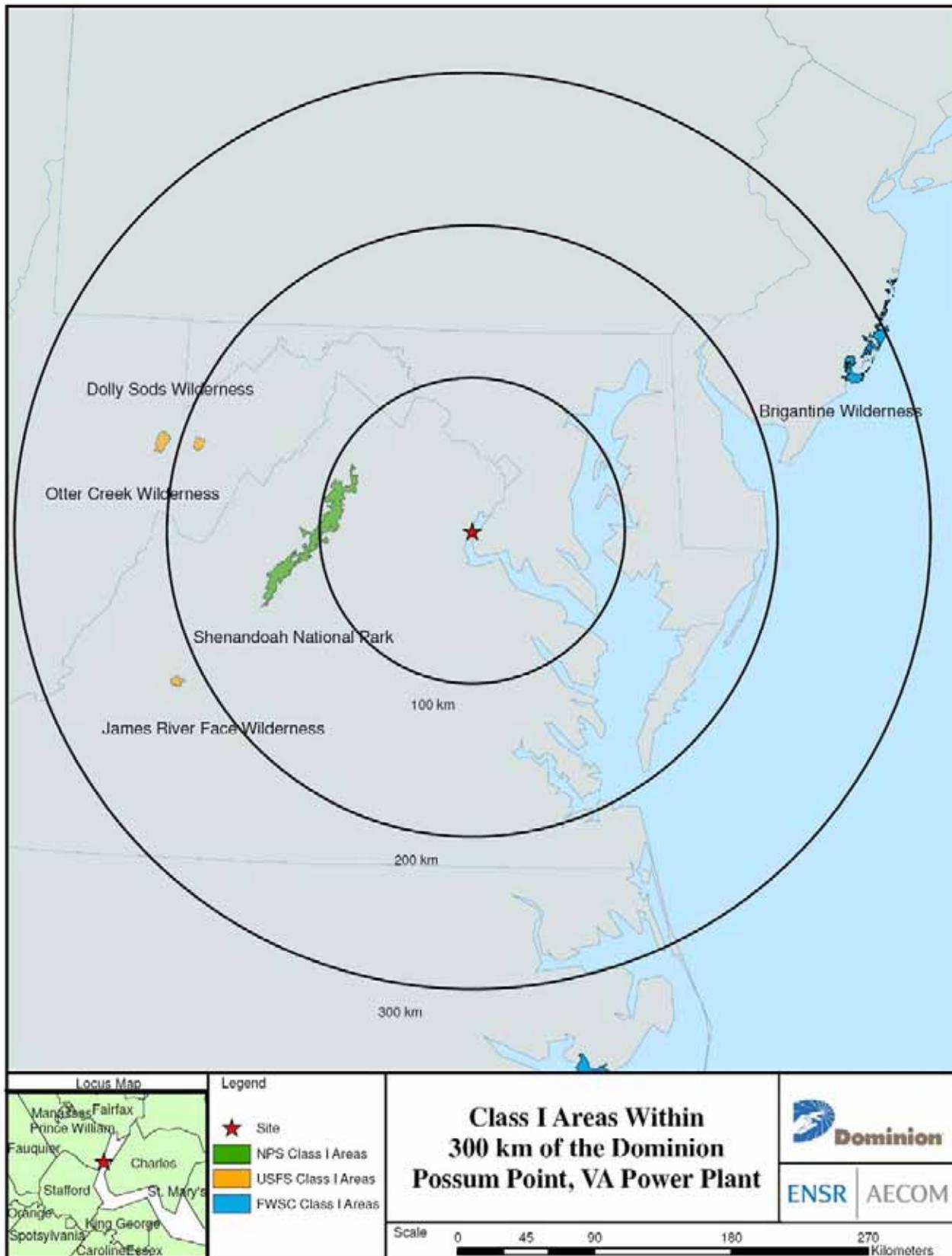
DEQ has determined that Unit 5 at Possum Point is BART-eligible for PM<sub>10</sub>. Figure 1-1 shows a plot of Possum Point relative to nearby Class I Areas. There are five Class I areas within 300 km of the plant:

- Shenandoah National Park (~94 km),
- Dolly Sods Wilderness (~185 km),
- Otter Creek Wilderness (~210 km),
- James River Face Wilderness (~213 km), and
- Brigantine Wilderness (~264 km).

### 1.3 Organization of Report Document

Section 2 of this report describes the source emissions that were used as input to the BART exemption modeling. Section 3 describes the input data that was used for the modeling, including the modeling domain, terrain and land use, and meteorological data. Section 4 describes the air quality modeling procedures and Section 5 discusses the modeling results. Since all of the references cited are also included in the VISTAS common BART modeling protocol (Section 7 of that document), no additional references section is included in this document. Appendices A and B provide additional information on the baseline source emissions. Appendix C includes a printout of excerpts of CALPOST list files.

Figure 1-1 Location of Class I Areas in Relation to Possum Point



## 2.0 Source Description and Emissions Data

### 2.1 Unit-Specific Source Data

The emissions data used to assess the visibility impacts at the Class I areas within 300 km of Possum Point is discussed in this section. DEQ has indicated that CAIR will satisfy BART for EGUs for SO<sub>2</sub> and NO<sub>x</sub>. Therefore, this BART exemption analysis focuses only on PM<sub>10</sub>. Since various components of PM<sub>10</sub> emissions have different visibility extinction efficiencies, the PM<sub>10</sub> emissions are divided, or “speciated,” into several components (VISTAS common protocol Sections 4.3.3 and 4.4.2). The VISTAS protocol (Section 5) allows for the use of source-specific emissions and speciation factors or default values from AP-42. The PM<sub>10</sub> emissions and speciation approach that were used for the modeling is indicated below.

Possum Point Unit 5 is a residual oil fired utility boiler with a mechanical collector for PM emission control. However, in order to be conservative, no credit is being taken for PM emission control. PM speciation is based on a methodology developed by the National Park Service based on AP-42 as described in Appendix A.

- Total PM<sub>10</sub> is comprised of filterable and condensable emissions.
- Baseline filterable PM<sub>10</sub> emissions are calculated based on 0.70% sulfur fuel with a heating value of 150,677 Btu/gal. Based on AP-42 and the National Park Service spreadsheet, filterable PM emissions are 8.31 lb/1,000 gal. Filterable PM<sub>10</sub> emissions, based on AP-42, are 71% of filterable PM emissions or 6.81 lb/1,000 . This PM<sub>10</sub> emission rate is used in the NPS spreadsheet with the heat input capacity to calculate the “maximum 24 hour average emission rate” as required by the VISTAS protocol.
- Filterable PM<sub>10</sub> is subdivided by size category, using the NPS spreadsheet, consistent with the default approach from AP-42 indicating that 27.1% of filterable PM<sub>10</sub> emissions is coarse (greater than 2.5 microns in size) and 72.9% is fine. Of the fine portion, 7.4% is elemental carbon and the remainder is inorganic fine particulates (soil).
- Condensable PM<sub>10</sub> consists of inorganic and organic compounds. The inorganic portion is by default assumed to be H<sub>2</sub>SO<sub>4</sub>, although other non-sulfate inorganic condensables could be present. The organic portion is modeled as organic aerosols.
- Condensable PM<sub>10</sub> emissions are calculated, using the NPS spreadsheet, consistent with AP-42. Total condensable PM<sub>10</sub> emissions are 1.5 lb/1,000 gallon of oil burned. Inorganic condensable PM<sub>10</sub> emissions are 85% of the total condensable PM<sub>10</sub> emissions and organic condensable PM<sub>10</sub> emissions are 15% of the total condensable PM<sub>10</sub> emissions.

In practice, CALPUFF allows for the user to input certain components of PM<sub>10</sub> as separate species and separate sizes, which will result in more accurate wet and dry deposition velocity results and also more accurate effects on light scattering. As noted above, the particle size distribution information is provided in AP-42 Table 1-1.6, and was used for the BART exemption modeling.

Table 2-1 provides a summary of the modeling emission parameters that were used in the BART exemption modeling, consistent with the source emissions data presented in Appendices A and B.

**Table 2-1 Possum Point Modeling Emissions and Stack Parameters<sup>1</sup>**

Case	Source / Unit	Location UTM (Zone 18 NAD-83)		Actual Stack Ht	Base Elev.	Flue Dia-meter	Gas Exit Vel.	Stack Gas Exit Temp.	Particle Speciation <sup>2</sup>							
		UTM East	UTM North						Filt. PM <sub>10</sub>	Coarse Soil	Fine PM	Fine Soil	EC	Cond. PM <sub>10</sub>	H <sub>2</sub> SO <sub>4</sub>	Organic
		M	M	m	M	m	m/s	deg K	lb/hr	lb/hr	lb/hr	Lb/hr	lb/hr	lb/hr	lb/hr	lb/hr
Baseline	Unit 5	301.19	4267.79	109.12	21.55	7.01	26.73	413.71	400.0	108.5	291.5	269.9	21.6	88.1	74.9	13.2
<b>Stack Basis Emissions Converted to g/sec</b>									<b>g/sec</b>	<b>g/sec</b>	<b>g/sec</b>	<b>g/sec</b>	<b>g/sec</b>	<b>g/sec</b>	<b>g/sec</b>	<b>g/sec</b>
Baseline	Unit 5	301.19	4267.79	109.12	21.55	7.01	26.73	413.71	50.40	13.67	36.73	34.01	2.72	11.10	9.44	1.66

<sup>1</sup> With Virginia being a CAIR-affected state, SO<sub>2</sub> and NO<sub>x</sub> emissions are not BART-applicable for EGU sources.

<sup>2</sup> Elemental carbon (EC) and fine PM are a part of filterable PM<sub>10</sub> and H<sub>2</sub>SO<sub>4</sub> and organics are a part of condensable PM<sub>10</sub>.

<sup>3</sup> Stack credit is equal to actual stack height since this stack is grandfathered.

## 3.0 Input Data to the CALPUFF Model

### 3.1 General Modeling Procedures

VISTAS has developed five sub-regional 4-km CALMET meteorological databases for three years (2001-2003). The sub-regional modeling domains are strategically designed to cover all potential BART eligible sources within VISTAS states and all PSD Class I areas within 300 km of those sources. The extents of the 4-km sub-regional domains are shown in Figure 4-4 of the VISTAS common BART modeling protocol. The BART exemption modeling for Possum Point was conducted with 4-km CALMET resolution from sub-domain #5. As shown in Figure 3-1, sub-domain 5 covers all of Virginia and the Class I areas needed for the exemption modeling analysis.

A computational grid was developed to be a subset of the sub-domain 5 meteorological grid. The computational grid was designed to include the three Class I areas and Possum Point along with a 50-km buffer. The additional 50-km distance allows for a sufficient buffer to enable puffs to recirculate. The computational grid extent in relation to the sub-domain #5 meteorological grid is shown in Figure 3-1.

USGS 90-meter Digital Elevation Model (DEM) files were used by VISTAS to generate the terrain data at 4-km resolution for input to the 4-km sub-regional CALMET run. Likewise, USGS 90-meter Composite Theme Grid (CTG) files were used by VISTAS to generate the land use data at 4-km resolution for input to the 4-km sub-regional CALMET run.

Three years of MM5 data (2001-2003) were used by VISTAS to generate the 4-km sub-regional meteorological datasets. See Sections 4.3.2 and 4.4.2 in the VISTAS common BART modeling protocol for more detail on the incorporation of MM5 data and surface observations into the CALMET wind field.

All exemption modeling was conducted using the 4-km CALMET data in sub-domain #5 along with a truncated computational grid.

### 3.2 Air Quality Database (Background Ozone and Ammonia)

Hourly measurements of ozone from all non-urban monitors within and just outside the computational grid, as generated by VISTAS (available at: [http://www.src.com/verio/download/sample\\_files.htm](http://www.src.com/verio/download/sample_files.htm)), was used as input to CALPUFF. The model default of 80 ppb was used for the background ozone concentration in the instance when all hourly data was missing for each station. As for the background ammonia value, VISTAS has recommended that a constant background value of 0.5 ppb should be used rather than using ammonia data derived from CMAQ model output. The exemption modeling conducted for the Possum Point follows these recommendations of VISTAS and uses 0.5 ppb as a constant ammonia background value.

### 3.3 Natural Conditions and Monthly f(RH) at Class I Areas

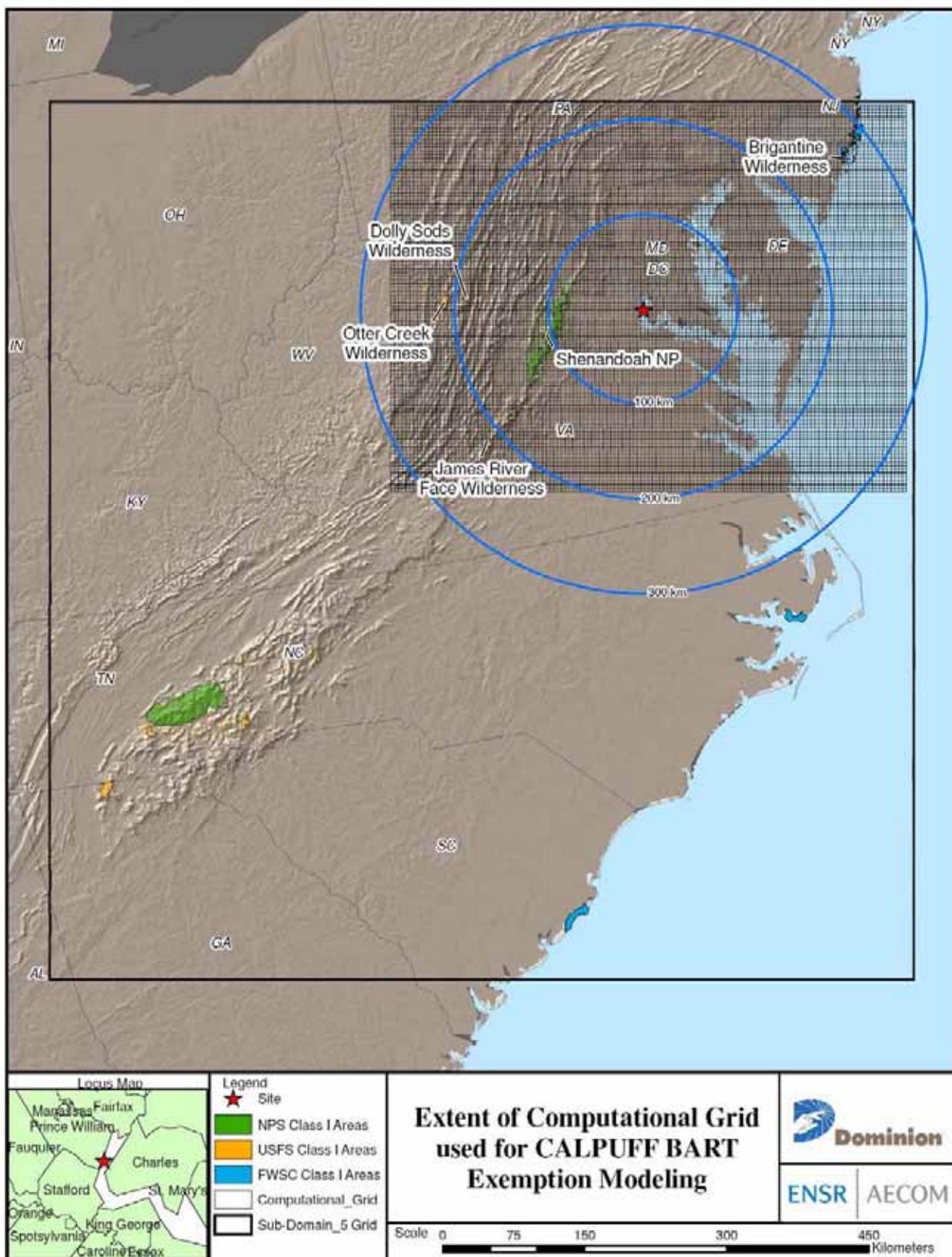
There are three Class I areas within 300 km of Possum Point (as noted in Figure 1-1). For each of the Class I areas, natural background conditions must be established in order to determine a change in natural conditions related to a source's emissions. For the BART exemption modeling, natural background light extinction corresponding to the annual average (EPA 2003) values were used as an initial estimate. This is consistent with guidance received from DEQ that allows for the use of the annual average background.

To determine the input to CALPUFF, it is first necessary to convert the deciviews to extinction using the equation:

Extinction ( $Mm^{-1}$ ) = 10 exp(deciviews/10).

For example, the EPA guidance document indicates for Swanquarter Wilderness Area that the deciview value for the annual average is 7.38. This is equivalent to an extinction of 20.92 inverse megameters ( $Mm^{-1}$ ).

This extinction includes the default 10  $Mm^{-1}$  for Rayleigh scattering. The remaining extinction is due to naturally occurring particles, and should be held constant for the entire year's simulation. Therefore, the data provided to CALPOST for Swanquarter was the total annual average natural background extinction minus 10 (expressed in  $Mm^{-1}$ ), or 10.92. This was most easily input as fine soil concentrations ( $10.92 \mu g/m^3$ ) in CALPOST, since the extinction efficiency of soil (PM-fine) is 1.0 and there is no f(RH) component. The concentration entries for all other particle constituents were set to zero, and the fine soil concentration was kept the same for each month of the year. The monthly values of f(RH) that CALPOST needs were taken from "Guidance for Tracking Progress Under the Regional Haze Rule" (EPA, 2003) Appendix A, Table A-3. These procedures were consistent with the "base case" VISTAS approach that did not account for site-specific changes to background due to naturally-occurring sea salt and near-sea-level Rayleigh scattering.

**Figure 3-1 Extent of Computational Grid**

## 4.0 Air Quality Modeling Procedures

This section provides a summary of the modeling procedures outlined in the VISTAS protocol that were used for the refined CALPUFF BART exemption modeling conducted for Possum Point Unit 5.

### 4.1 Model Selection and Features

As recommended in the VISTAS protocol, this exemption modeling uses the BART-specific versions of CALMET and CALPUFF posted at [http://www.src.com/verio/download/download.htm#VISTAS\\_VERSION](http://www.src.com/verio/download/download.htm#VISTAS_VERSION). These versions contain enhancements funded by the Minerals Management Service (MMS) and VISTAS. They are maintained on TRC's website for public access. This release includes CALMET, CALPUFF, CALPOST, CALSUM, and POSTUTIL as well as CALVIEW.

The major features of the CALPUFF modeling system, including those of CALMET and the post-processors (CALPOST and POSTUTIL), are referenced in Section 3 of the VISTAS protocol.

### 4.2 Modeling Domain and Receptors

The Possum Point runs used the 4-km CALMET data in sub-domain #5 that was supplied by VISTAS, as discussed above. A computational grid was developed to be a subset of the sub-domain #5 meteorological grid. The computational grid was designed to include the three Class I areas and Possum Point along with a 50-km buffer. The additional 50-km distance allowed for a sufficient buffer to enable puffs to recirculate. The computational grid extent in relation to the sub-domain #5 meteorological grid is shown in Figure 3-1.

The receptors used for each of the Class I areas are based on the NPS database of Class I receptors, as recommended by the VISTAS common protocol (Section 4.3.3).

### 4.3 Technical Options Used in the Modeling

CALMET modeling for the VISTAS 4-km sub-domains was pre-determined by the VISTAS contractor, and, therefore, we assume that VISTAS approves of the manner in which CALMET has been run for the sub-domain data that they provide.

For CALPUFF model options, Possum Point followed the VISTAS common BART modeling protocol (Section 4.4.1), which states that we should use IWAQM (EPA, 1998) guidance. The VISTAS protocol also notes that building downwash effects are not required to be included unless the state directs the source to include these effects. Possum Point did not include building downwash effects in the CALPUFF modeling.

The POSTUTIL utility program (described in VISTAS common protocol Section 4.4.2) was used to repartition HNO<sub>3</sub> and NO<sub>3</sub> concentrations using the constant ammonia background value of 0.5 ppb.

### 4.4 Light Extinction and Haze Impact Calculations

The CALPOST postprocessor was used as prescribed in the VISTAS protocol for the calculation of light extinction due to the impact from the modeled source's primary and secondary particulate matter. The assessment of visibility impacts at the Class I areas used CALPOST Method 6 (as noted in the VISTAS common protocol Section 4.3.2). Each hour's source-caused extinction is calculated by first using the hygroscopic components of the source-caused concentrations due to ammonium sulfate, and monthly Class I area-specific f(RH) values (see Table 4-1). The contribution to the total source-caused extinction from ammonium sulfate is then added to the other, non-hygroscopic components of the particulate concentration

(from coarse and fine soil, secondary organic aerosols, and from elemental carbon) to yield the total hourly source-caused extinction.

The formula that was used to calculate the extinction is the existing (not the November 2005 revised) IMPROVE/EPA formula, which is applied to determine a change in light extinction due to increases in the particulate matter concentrations. Using the notation of CALPOST, the formula is the following:

$$b_{ext} = 3 f(RH) [(NH_4)_2SO_4] + 3 f(RH) [ NH_4NO_3 ] + 4[OC] + 1[Soil] + 0.6[Coarse Mass] + 10[EC] + b_{Ray}$$

The concentrations, in square brackets, are in  $\mu\text{g}/\text{m}^3$  and  $b_{ext}$  is in units of  $\text{Mm}^{-1}$ . The Rayleigh scattering term ( $b_{Ray}$ ) has a default value of  $10 \text{ Mm}^{-1}$ , as recommended in EPA guidance for tracking reasonable progress (EPA, 2003a).

In this exemption modeling analysis for Possum Point Unit 5, we used site-specific monthly  $f(RH)$  values and annual average background concentrations from Appendices A and B of the "Guidance for Estimating Natural Visibility Under the Regional Haze Rule" EPA 2003. Table 4-1 summarizes the monthly  $f(RH)$  and annual average concentrations used as input to CALPOST.

The BART rule significance threshold for the contribution to visibility impairment is 0.5 deciviews. The VISTAS protocol (Section 4.3.2) indicates that with the use of the 4-km sub-regional CALMET database, a source does not cause or contribute to visibility impairment if the 98<sup>th</sup> percentile (or 8<sup>th</sup> highest) day's change in extinction from natural conditions does not exceed 0.5 deciviews for any of the modeled years. As an added check, the 22<sup>nd</sup> highest prediction over the three years modeled should also not exceed 0.5 deciviews for a source to be exempted from a BART determination.

Figure 4-1 of the VISTAS common BART modeling protocol presents a flow chart showing the components of that modeling protocol for the analysis to determine whether a source is subject to BART. It should be noted that the modeling for Possum Point focused on sub-regional fine-scale modeling as depicted in the lower half of the figure.

The exemption modeling results for the BART-eligible units at Possum Point are presented in Section 5.

**Table 4-1 Annual Average Background and Monthly  $f(RH)$  used in CALPOST**

Class I Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>Monthly <math>f(RH)</math></b>												
Brigantine W	2.8	2.6	2.7	2.6	3.0	3.2	3.4	3.7	3.6	3.3	2.9	2.8
Dolly Sods W	3.0	2.8	2.8	2.6	3.1	3.4	3.5	3.9	3.9	3.3	3.0	3.1
James River Face W	2.8	2.6	2.7	2.4	3.0	3.3	3.4	3.7	3.6	3.2	2.8	3.0
Otter Creek W	3.0	2.8	2.8	2.6	3.2	3.5	3.7	4.1	4.0	3.3	3.0	3.1
Shenandoah NP	3.1	2.8	2.8	2.5	3.1	3.4	3.5	3.9	3.9	3.2	3.0	3.1
<b>Annual Average Background<sup>(1)</sup> (<math>\text{Mm}^{-1}</math>)</b>												
Brigantine W	11.04 (same for all months)											
Dolly Sods W	11.13 (same for all months)											
James River Face W	10.96 (same for all months)											
Otter Creek W	11.15 (same for all months)											
Shenandoah NP	10.98 (same for all months)											

(1) Value is adjusted to remove the default Rayleigh scattering coefficient of  $10 \text{ Mm}^{-1}$ .

## 5.0 Presentation of Modeling Results

The exemption modeling results for Unit 5 at Possum Point are provided in Table 5-1. Appendix B lists delta-deciview results for the top 20 days for each year modeled at each Class I area. The table indicates that both the highest and the 8th highest day's impacts for each year are below 0.5 dv. These results demonstrate that Possum Point Unit 5 PM<sub>10</sub> emissions do not cause or contribute to regional haze in any Class I area within 300 km of the source. Therefore, the Possum Point Unit 5 is not "subject to BART" and no further BART analysis is required.

**Table 5-1 Summary of Results – Possum Point Refined BART Exemption Modeling**

Class I area	Distance (km) from source to Class I area boundary	# of days with impact > 0.5 dv in Class I area				Max. 24-hr impact over 3- yr period (dv)	8 <sup>th</sup> highest impact over 3- yr period (dv)
		2001	2002	2003	3-yr		
Shenandoah, VA	~ 94 km	2	3	5	10	0.691	0.414
Dolly Sods, WV	~ 185 km	0	0	0	0	0.144	0.050
Otter Creek, WV	~ 210 km	0	0	0	0	0.126	0.039
James River Face, VA	~ 213 km	0	0	0	0	0.217	0.080
Brigantine, NJ	~ 264 km	0	0	0	0	0.141	0.100

## Appendix A

### **Basis for Source-Specific PM<sub>10</sub> Speciation and Sulfuric Acid Emissions for BART Baseline Case**

Possum Point Unit 5 is a residual oil fired utility boiler with a mechanical collector for PM emission control. However, in order to be conservative, no credit is being taken for PM emission control. PM speciation is based on a methodology developed by the National Park Service based on AP-42. Details on the NPS methodology follow the table on Page A-3 below.

## Possum Pt. #5

Controlled PM10 Speciation from AP-42 Tables 1.3-2 &amp; 1.3-4

Uncontrolled Utility Residual Oil Boiler

Fuel oil is	<b>6</b>	oil with a sulfur content of <b>0.70 %S</b> ; therefore, A =	<b>1.154</b>									
Heating value is	<b>150,877</b>	Btu/Gal	and the maximum 24-hour average actual heat input is	<b>8,851</b>	MMBtu/hr							

Uncontrolled PM10 Emissions (bold values from Tables 1.3-2 and 1.3-4)																
Boiler	Total PM10 (lb/mmBtu)	Filtrable (lb/mmBtu)	Coarse (lb/mmBtu)	Ext. Coef.	Fine (lb/mmBtu)	Fine Soil (lb/mmBtu)	Ext. Coef.	Fine EC (lb/mmBtu)	Ext. Coef.	Condensable (lb/mmBtu)	CPM IOR (lb/mmBtu)	Particle Type	Ext Coef.	CPM OR (lb/mmBtu)	Particle Type	Ext Coef.
Utility	<b>8.31</b>	<b>6.81</b>	<b>1.85</b>	<b>0.6</b>	<b>4.96</b>	<b>4.59</b>	<b>1</b>	<b>0.37</b>	<b>10</b>	<b>1.5</b>	<b>1.29</b>	<b>SO4</b>	<b>37(RH)</b>	<b>0.23</b>	<b>SOA</b>	<b>4</b>

Uncontrolled PM10 Emissions																
Boiler	Total PM10 (% of Total)	Filtrable (% of Total)	Coarse (% of Total)	Ext. Coef.	Fine (% of Total)	Fine Soil (% of Total)	Ext. Coef.	Fine EC (% of Total)	Ext. Coef.	Condensable (% of Total)	CPM IOR (% of Total)	Particle Type	Ext Coef.	CPM OR (% of Total)	Particle Type	Ext Coef.
Utility	<b>100%</b>	<b>81.9%</b>	<b>22.2%</b>	<b>0.6</b>	<b>59.7%</b>	<b>56.3%</b>	<b>1</b>	<b>4.4%</b>	<b>10</b>	<b>18.1%</b>	<b>15.3%</b>	<b>SO4</b>	<b>37(RH)</b>	<b>2.7%</b>	<b>SOA</b>	<b>4</b>

Uncontrolled PM10 Emissions																
Boiler	Total PM10 (lb/mmBtu)	Filtrable (lb/mmBtu)	Coarse (lb/mmBtu)	Ext. Coef.	Fine (lb/mmBtu)	Fine Soil (lb/mmBtu)	Ext. Coef.	Fine EC (lb/mmBtu)	Ext. Coef.	Condensable (lb/mmBtu)	CPM IOR (lb/mmBtu)	Particle Type	Ext Coef.	CPM OR (lb/mmBtu)	Particle Type	Ext Coef.
Utility	<b>0.96</b>	<b>0.05</b>	<b>0.61</b>	<b>0.6</b>	<b>0.03</b>	<b>0.03</b>	<b>1</b>	<b>0.002</b>	<b>10</b>	<b>0.01</b>	<b>0.01</b>	<b>SO4</b>	<b>37(RH)</b>	<b>0.001</b>	<b>SOA</b>	<b>4</b>

If you are given Total PM10 emissions in lb/hr:

Uncontrolled PM10 Emissions (bold value is Input by user)																
Boiler	Total PM10 (lb/hr)	Filtrable (lb/hr)	Coarse (lb/hr)	Ext. Coef.	Fine (lb/hr)	Fine Soil (lb/hr)	Ext. Coef.	Fine EC (lb/hr)	Ext. Coef.	Condensable (lb/hr)	CPM IOR (lb/hr)	Particle Type	Ext Coef.	CPM OR (lb/hr)	Particle Type	Ext Coef.
Utility	<b>488.1</b>	<b>400.0</b>	<b>100.5</b>	<b>0.6</b>	<b>291.5</b>	<b>269.9</b>	<b>1</b>	<b>21.6</b>	<b>10</b>	<b>68.1</b>	<b>74.8</b>	<b>SO4</b>	<b>3</b>	<b>13.2</b>	<b>SOA</b>	<b>4</b>

Weighted Extinction: 65.1

269.9 215.7 224.7 82.9

If you are given Total PM10 emissions in lb/mmBtu:

Uncontrolled PM10 Emissions (bold value is Input by user)																
Boiler	Total PM10 (lb/mmBtu)	Filtrable (lb/mmBtu)	Coarse (lb/mmBtu)	Ext. Coef.	Fine (lb/mmBtu)	Fine Soil (lb/mmBtu)	Ext. Coef.	Fine EC (lb/mmBtu)	Ext. Coef.	Condensable (lb/mmBtu)	CPM IOR (lb/mmBtu)	Particle Type	Ext Coef.	CPM OR (lb/mmBtu)	Particle Type	Ext Coef.
Utility	<b>0.655</b>	<b>0.045</b>	<b>0.012</b>	<b>0.6</b>	<b>0.033</b>	<b>0.030</b>	<b>1</b>	<b>0.002</b>	<b>10</b>	<b>0.010</b>	<b>0.008</b>	<b>SO4</b>	<b>3</b>	<b>0.001</b>	<b>SOA</b>	<b>4</b>

Uncontrolled PM10 Emissions (bold values from Table 1.3-2 and from Table 6 of EPA's January 2002 DRAFT "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon")																
Boiler	Total PM10 (% of Total)	Filtrable (% of Total)	Coarse (% of Total)	Ext. Coef.	Fine (% of Total)	Fine Soil (% of Total)	Ext. Coef.	Fine EC (% of Total)	Ext. Coef.	Condensable (% of Total)	CPM IOR (% of Total)	Particle Type	Ext Coef.	CPM OR (% of Total)	Particle Type	Ext Coef.
Utility	<b>100%</b>	<b>81.9%</b>	<b>27.1%</b>	<b>0.6</b>	<b>72.9%</b>	<b>67.5%</b>	<b>1</b>	<b>5.4%</b>	<b>10</b>	<b>18.1%</b>	<b>85%</b>	<b>SO4</b>	<b>3</b>	<b>15%</b>	<b>SOA</b>	<b>4</b>

(% of Fine): 92.6% 1 7.4% 10

Uncontrolled PM10 Emissions (bold value is Input by user)																
Boiler	Total PM10 (lb/hr)	Filtrable (lb/hr)	Coarse (lb/hr)	Ext. Coef.	Fine (lb/hr)	Fine Soil (lb/hr)	Ext. Coef.	Fine EC (lb/hr)	Ext. Coef.	Condensable (lb/hr)	CPM IOR (lb/hr)	Particle Type	Ext Coef.	CPM OR (lb/hr)	Particle Type	Ext Coef.
Utility	<b>488.1</b>	<b>400.8</b>	<b>100.5</b>	<b>0.6</b>	<b>291.5</b>	<b>269.9</b>	<b>1</b>	<b>21.6</b>	<b>10</b>	<b>68.1</b>	<b>74.8</b>	<b>SO4</b>	<b>3</b>	<b>13.2</b>	<b>SOA</b>	<b>4</b>

If you are given Filterable PM10 emissions in lb/mmBtu:

Uncontrolled PM10 Emissions (bold value is Input by user)																
Boiler	Total PM10 (lb/mmBtu)	Filtrable (lb/mmBtu)	Coarse (lb/mmBtu)	Ext. Coef.	Fine (lb/mmBtu)	Fine Soil (lb/mmBtu)	Ext. Coef.	Fine EC (lb/mmBtu)	Ext. Coef.	Condensable (lb/mmBtu)	CPM IOR (lb/mmBtu)	Particle Type	Ext Coef.	CPM OR (lb/mmBtu)	Particle Type	Ext Coef.
Utility	<b>0.056</b>	<b>0.045</b>	<b>0.012</b>	<b>0.6</b>	<b>0.033</b>	<b>0.030</b>	<b>1</b>	<b>0.002</b>	<b>10</b>	<b>0.010</b>	<b>0.008</b>	<b>SO4</b>	<b>3</b>	<b>0.001</b>	<b>SOA</b>	<b>4</b>

PM10 Results															
Modal Input Data															
Coarse	22.2%	Fine	66.3%	Ext.	100.5	Fine EC	4.4%	Ext.	10	Condensable	18.3%	Particle	CPM OR	Particle	CPM OR
Fine Soil	66.3%	Fine EC	21.6	Ext.	291.5	Fine EC	4.4%	Ext.	10	CPM IOR	18.3%	CPM OR	13.2	SOA	4
Fine EC	4.4%	Fine EC	21.6	Ext.	291.5	Fine EC	4.4%	Ext.	10	CPM IOR	18.3%	CPM OR	13.2	SOA	4
CPM IOR	18.3%	CPM IOR	74.8	Ext.	74.8	CPM IOR	74.8	Ext.	10	Condensable	18.3%	Particle	CPM OR	Particle	CPM OR
CPM OR	2.7%	CPM OR	13.2	Ext.	13.2	CPM OR	13.2	Ext.	10	Condensable	18.3%	Particle	CPM OR	Particle	CPM OR
Total	100.0%	Total	488.1	lb/hr											

(a) Dominion Input data are shown in bold red font.

PM10 Speciation based on AP-42 emission factors - NPS spreadsheet STACK TEST YORKTOWN.xls

Possum Pt. #5

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**Particulate Matter Speciation**

**Oil-Fired Boiler PM<sub>10</sub>**

Recommendations for modeling the particulate matter (PM<sub>10</sub>) speciation for three types of Utility Oil-fired boilers (Uncontrolled, with Scrubber, and with ESP) and two types of Industrial Oil-fired boilers (Uncontrolled, and Multicyclone), are contained in the Excel workbooks available in the Highlights box. Instructions for using the workbooks are available below.

**Highlights**

- Uncontrolled Industrial Oil Boiler Example (Excel XP Format, 55 kb, updated 03/2006)
- Uncontrolled Utility Oil Boiler Example (Excel XP Format, 55 kb, updated 03/2006)
- Industrial Oil Boiler MultiCyclone Example (Excel XP Format, 55 kb, updated 03/2006)
- Utility Oil Boiler ESP Example (Excel XP Format, 55 kb, updated 03/2006)
- Utility Oil Boiler Scrubber Example (Excel XP Format, 55 kb, updated 03/2006)

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The derivation of these values is based on data from AP-42, Section 1.3 (Fuel Oil Combustion), as described below. Any individual source may deviate from these recommendations with the conditional approval of the Federal Land Manager (FLM) and the Regulatory Authority. Applicants seeking approval of an alternate speciation profile should submit stack testing data or other documentation supporting use of a different profile for the source in question. Where a different speciation profile is approved, the FLMs may request that the Regulatory Authority include emissions testing requirements in the source's permit to confirm the validity of the alternate profile.

The filterable PM<sub>10</sub> represents the emissions captured using the Method 5 "front-half" filter and the condensable PM<sub>10</sub> represents the emissions captured using the Method 202 "back half" method. Filterable emissions consist of mostly fine and coarse ash from combustion, plus some unburned carbon from the fuel. In modern boiler systems, the fuel combustion should be nearly complete, so it can be assumed that most of the filterable PM<sub>10</sub> will be inorganic flyash material.

Filterable PM<sub>10</sub> mass is speciated as follows. Filterable PM<sub>10</sub> size speciation data are given in AP-42 Tables 1.3-4 and 13-5. Filterable mass sized 2.5 microns or less fall into the fine PM<sub>10</sub> category when calculating light extinction with the CALPUFF system. Although most of the fine PM<sub>10</sub> has a light extinction coefficient (B<sub>ext</sub>) of 1.0, the FLMs will assume that a nominal 7.4% of the fine PM<sub>10</sub> emissions is unburned elemental carbon contained in the flyash<sup>1</sup>. The remainder of the filterable PM<sub>10</sub> is coarse PM<sub>10</sub> which has a light extinction coefficient (B<sub>ext</sub>) of 0.6.

For the condensable PM<sub>10</sub> emissions, AP-42 Table 1.3-2 separates the condensable PM<sub>10</sub> into "inorganic" and "organic", with 85% of the condensable PM<sub>10</sub> listed as inorganic and 15% listed as organic for residual oil-fired boilers. The organic/inorganic breakout is believed to be based on the fraction of the condensable PM collected in the "solvent extractable" portion of Method 202.

It is assumed that the "organic" condensable PM<sub>10</sub> (CPM OR) is comprised of

Secondary Organic Aerosols (SOA) with a light extinction coefficient of 4.0. The "inorganic" condensable PM<sub>10</sub> (CPM IOR) is assumed comprised of sulfate (SO<sub>4</sub><sup>2-</sup>) with a light extinction coefficient of 3.0 \* f (RH), which accounts for the hygroscopic growth of sulfate aerosol in the presence of water vapor. This growth in particle size increases the light-scattering abilities of the sulfate aerosols<sup>2</sup>.

The recommended PM<sub>10</sub> speciation should be applied to the PM<sub>10</sub> emission rate estimated for the source. Ideally, both the "filterable" and "condensable" PM<sub>10</sub> emissions would be provided. Also, for modeling of visibility impacts and 24-hour PM<sub>10</sub> NAAQS and PSD increments, the PM<sub>10</sub> emission rate input to CALPUFF should not represent a compliance averaging time of longer than 24-hours.

### Using the Workbooks

**PLEASE NOTE: These workbooks are not "recyclable". Depending upon how you use them, certain links may be broken that would be essential for a different application. Download the workbook, rename the workbook before beginning any calculations, and use a new workbook for each application.**

**It should also be noted that these workbooks were developed primarily for application to existing boilers for which there may be no explicit limits on pollutants such as H<sub>2</sub>SO<sub>4</sub>. However, for new boilers for which information may be available on multiple PM<sub>10</sub> constituents, the workbooks can be modified to incorporate that additional data.**

Select the Excel workbook that most closely resembles the boiler in question. The **bold** values in the magenta cells in rows five and six of the spreadsheets are dummy values for fuel quality (oil grade, heating value, % sulfur), heat input rate (mmBtu/hr), and humidity (f(RH)); the user should substitute actual values for fuel quality (and heat input rate if emissions are to be input in lb/mmBtu). **Because oil-fired boilers without FGDs are very sensitive to fuel grade and sulfur content, care should be taken to enter the correct values for these units.** (You can ignore the f(RH) value which is included to test the effect of humidity on relative light extinction of the various species.) Except as indicated, the **bold** values in the body of the spreadsheets represent data that were entered directly and originated in either AP-42 Table 1.3-2, 1.3-4, and 1.3-5, or, in the case of the "7.4% of Fines" value for elemental carbon, from Table 6 of EPA's January 2002 **DRAFT** "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon". **Unless entering "custom" values, do not change any value in a cell that is not both bold and colored magenta, orange, or yellow.**

Based upon the emissions data available (total or filterable PM<sub>10</sub> in lb/hr or lb/mmBtu), enter the emission rate into the appropriate (orange or yellow) cell with a corresponding dummy value. Corresponding emission rates for filterables and condensables will show up in the green cells, and **emission rates for each species of condensables will appear in the blue cells—use these values. All condensable PM<sub>10</sub> is considered to be submicron.**

In order to separate filterable PM<sub>10</sub> emissions by size, the AP-42 Table 1.3-2, 1.3-4, and 1.3-5 size fractions for the appropriate boiler and controls were used. The resulting charts show filterable PM<sub>10</sub> emissions in lb/hr for size ranges modeled by CALPUFF. Match the proper species with the correct size range. The assumption is

made that coarse PM<sub>10</sub> is between 2.5 and 10 micron, and the corresponding emission rates are shown in the blue cells in the "PM Size" table. It is assumed that elemental carbon represents a small percentage of the fine PM<sub>10</sub> and is all in the smallest CALPUFF size range (magenta cells). The remaining fine soil was assigned to the size range below 2.5 micron, and the results are shown in the blue cells (in g/sec). Please note that the smallest CALPUFF size range (magenta cells) has been split to show entries for fine soil and elemental carbon.

Neither the filterable PM<sub>10</sub> speciation spreadsheet nor its associated charts will work unless the correct value is calculated for total filterable PM<sub>10</sub> emissions (in lb/hr).

There are several ways to do this, depending upon the type of emissions data initially input:

- If you enter Total PM<sub>10</sub> in lb/hr (into orange cell C28), everything is calculated automatically for you.
- If you enter Total PM<sub>10</sub> in lb/mmBtu (into orange cell C35), you need to make sure that you have also entered the production rate into (magenta) cell I6; then, everything is calculated automatically for you.
- If you enter Filterable PM<sub>10</sub> in lb/hr (into yellow cell E47), the spreadsheet will calculate Total PM<sub>10</sub> (in lb/hr) in (green) cell C47. Transfer that value to (orange) cell C28, and everything is calculated automatically for you.
- If you enter Filterable PM<sub>10</sub> in lb/mmBtu (into yellow cell E53), the spreadsheet will calculate Total PM<sub>10</sub> (in green cell C46) in lb/mmBtu. Transfer that value to (orange) cell C35, and everything is calculated automatically for you, provided that you have entered the production rate into (magenta) cell I6.

Or, you can enter the Filterable PM<sub>10</sub> emission rate (in lb/hr) directly into (yellow) cell E26 of the "PM (Size)" table.

If you have questions, comments, or suggestions, please contact Don Shepherd at the National Park Service, Air Resources Division in Denver at 303-969-2075 or contact us through the Webmaster link at the bottom of the page.

<sup>1</sup> Table 6 of EPA's January 2002 DRAFT "Catalog of Global Emissions Inventories and Emission Inventory Tools for Black Carbon".

<sup>2</sup> The values in row 29 of the tables result from an experiment in which we were trying to understand the effect of coal quality and f(RH) on the overall extinction from a given PM speciation profile.

TOP OF PAGE

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## Appendix B

### **CALPOST List Files for Shenandoah, Dolly Sods, Otter Creek, James River Face, and Brigantine**

## Ranked Daily Visibility Change for Shenandoah (Top 20 Days for Each Year)

YEAR	DAY	HR	REC	DV(Total)	DV(BKG)	DELTA DV	f(RH)	% of Modeled Extinction by Species						
								%_SO4	%_NO3	%_OC	%_EC	%_PMC	%_PMF	
2001	80	0	392	8.05	7.41	0.64	2.8	58.53	0	3.65	14.92	4.27	18.64	1
2001	166	0	385	7.932	7.41	0.522	3.4	63.32	0	3.25	13.29	3.53	16.61	2
2001	128	0	543	7.897	7.41	0.487	3.1	61.08	0	3.44	14.06	3.85	17.57	3
2001	64	0	430	7.887	7.41	0.477	2.8	58.57	0	3.65	14.93	4.19	18.66	4
2001	347	0	370	7.777	7.41	0.368	3.1	61.02	0	3.43	14.05	3.95	17.55	5
2001	202	0	392	7.753	7.41	0.343	3.5	63.92	0	3.19	13.03	3.58	16.29	6
2001	127	0	522	7.739	7.41	0.329	3.1	61.69	0	3.47	14.2	2.89	17.75	7
2001	203	0	551	7.723	7.41	0.313	3.5	64.01	0	3.19	13.05	3.44	16.31	8
2001	141	0	546	7.716	7.41	0.307	3.1	61.41	0	3.46	14.14	3.33	17.67	9
2001	142	0	553	7.693	7.41	0.283	3.1	61.17	0	3.44	14.08	3.71	17.6	10
2001	19	0	539	7.686	7.41	0.277	3.1	60.92	0	3.43	14.03	4.1	17.53	11
2001	167	0	370	7.654	7.41	0.244	3.4	63.31	0	3.25	13.29	3.54	16.61	12
2001	92	0	513	7.651	7.41	0.241	2.5	55.88	0	3.9	15.95	4.33	19.93	13
2001	305	0	422	7.644	7.41	0.234	3.2	61.75	0	3.37	13.77	3.91	17.21	14
2001	343	0	258	7.63	7.41	0.22	3.1	61.3	0	3.45	14.11	3.5	17.63	15
2001	212	0	258	7.588	7.41	0.178	3.5	64.25	0	3.2	13.1	3.08	16.37	16
2001	40	0	315	7.583	7.41	0.173	2.8	58.59	0	3.65	14.93	4.17	18.66	17
2001	54	0	539	7.58	7.41	0.17	2.8	58.99	0	3.68	15.03	3.52	18.79	18
2001	44	0	538	7.579	7.41	0.169	2.8	58.68	0	3.66	14.96	4.01	18.69	19
2001	333	0	552	7.574	7.41	0.164	3	60.49	0	3.52	14.39	3.61	17.98	20
2002	296	0	468	8.038	7.41	0.628	3.2	61.74	0	3.37	13.77	3.92	17.21	1
2002	269	0	422	7.982	7.41	0.572	3.9	66.27	0	2.96	12.13	3.49	15.15	2
2002	251	0	551	7.979	7.41	0.569	3.9	66.8	0	2.99	12.22	2.72	15.27	3
2002	240	0	460	7.812	7.41	0.403	3.9	66.43	0	2.97	12.16	3.25	15.19	4
2002	86	0	414	7.758	7.41	0.349	2.8	58.69	0	3.66	14.96	4	18.69	5
2002	270	0	392	7.744	7.41	0.334	3.9	66.32	0	2.97	12.14	3.41	15.17	6
2002	102	0	551	7.692	7.41	0.282	2.5	55.87	0	3.9	15.95	4.35	19.93	7
2002	85	0	552	7.673	7.41	0.263	2.8	59.62	0	3.71	15.2	2.47	18.99	8
2002	254	0	258	7.669	7.41	0.259	3.9	66.44	0	2.97	12.16	3.23	15.19	9
2002	244	0	344	7.662	7.41	0.252	3.9	66.69	0	2.98	12.2	2.87	15.25	10
2002	253	0	262	7.66	7.41	0.25	3.9	66.99	0	3	12.26	2.44	15.32	11
2002	252	0	538	7.65	7.41	0.24	3.9	67.46	0	3.02	12.34	1.76	15.42	12
2002	298	0	285	7.645	7.41	0.235	3.2	62.01	0	3.38	13.83	3.49	17.28	13
2002	32	0	350	7.644	7.41	0.234	3.1	61.38	0	3.45	14.13	3.38	17.66	14
2002	353	0	360	7.633	7.41	0.224	3.1	61.15	0	3.44	14.08	3.74	17.59	15
2002	241	0	549	7.629	7.41	0.219	3.9	66.24	0	2.96	12.12	3.52	15.15	16
2002	289	0	468	7.625	7.41	0.216	3.2	61.98	0	3.38	13.82	3.55	17.27	17
2002	207	0	256	7.617	7.41	0.207	3.5	64.2	0	3.2	13.09	3.15	16.36	18
2002	299	0	551	7.601	7.41	0.191	3.2	61.83	0	3.37	13.79	3.78	17.23	19
2002	77	0	498	7.574	7.41	0.164	2.8	58.58	0	3.65	14.93	4.18	18.66	20
2003	323	0	543	8.101	7.41	0.691	3	60.17	0	3.5	14.31	4.14	17.89	1
2003	284	0	314	8.059	7.41	0.649	3.2	61.9	0	3.37	13.81	3.67	17.25	2
2003	281	0	430	8.024	7.41	0.614	3.2	61.9	0	3.37	13.81	3.67	17.25	3
2003	212	0	448	7.92	7.41	0.51	3.5	64.28	0	3.2	13.11	3.03	16.38	4
2003	79	0	452	7.918	7.41	0.508	2.8	58.69	0	3.66	14.96	4.01	18.69	5
2003	58	0	482	7.909	7.41	0.499	2.8	58.76	0	3.66	14.98	3.89	18.71	6
2003	253	0	258	7.906	7.41	0.496	3.9	66.41	0	2.97	12.15	3.28	15.19	7
2003	255	0	331	7.824	7.41	0.414	3.9	66.37	0	2.97	12.15	3.33	15.18	8
2003	280	0	385	7.796	7.41	0.387	3.2	62.04	0	3.38	13.84	3.46	17.29	9
2003	108	0	385	7.77	7.41	0.361	2.5	56.75	0	3.96	16.2	2.85	20.24	10
2003	213	0	532	7.757	7.41	0.347	3.5	63.88	0	3.18	13.03	3.64	16.28	11
2003	220	0	385	7.747	7.41	0.337	3.9	66.5	0	2.97	12.17	3.15	15.21	12
2003	98	0	551	7.732	7.41	0.322	2.5	55.87	0	3.9	15.95	4.35	19.93	13
2003	256	0	391	7.725	7.41	0.315	3.9	66.33	0	2.97	12.14	3.4	15.17	14
2003	31	0	390	7.703	7.41	0.293	3.1	61.34	0	3.45	14.12	3.44	17.65	15
2003	322	0	468	7.698	7.41	0.288	3	60.09	0	3.49	14.3	4.26	17.86	16
2003	348	0	406	7.689	7.41	0.28	3.1	60.95	0	3.43	14.03	4.05	17.53	17
2003	169	0	551	7.684	7.41	0.274	3.4	63.54	0	3.26	13.34	3.2	16.66	18
2003	168	0	552	7.681	7.41	0.271	3.4	63.97	0	3.28	13.43	2.55	16.78	19
2003	315	0	531	7.668	7.41	0.259	3	60.3	0	3.51	14.34	3.93	17.92	20

## Ranked Daily Visibility Change for Dolly Sods ( Top 20 Days for Each Year)

YEAR	DAY	HR	REC	DV(Total)	DV(BKG)	DELTA DV	f(RH)	% of Modeled Extinction by Species						%_PMF	Ranking
								%_SO4	%_NO3	%_OC	%_EC	%_PMC			
2001	64	0	17	7.591	7.481	0.11	2.8	59.13	0	3.68	15.07	3.29	18.83	1	
2001	347	0	36	7.588	7.481	0.107	3.1	61.74	0	3.47	14.21	2.81	17.76	2	
2001	167	0	71	7.576	7.481	0.095	3.4	63.54	0	3.26	13.34	3.2	16.67	3	
2001	127	0	79	7.566	7.481	0.084	3.1	62.29	0	3.51	14.34	1.94	17.92	4	
2001	202	0	71	7.564	7.481	0.083	3.5	64.38	0	3.21	13.13	2.88	16.4	5	
2001	80	0	17	7.547	7.481	0.065	2.8	59.65	0	3.72	15.2	2.44	19	6	
2001	203	0	27	7.517	7.481	0.036	3.5	65.31	0	3.26	13.32	1.47	16.64	7	
2001	247	0	79	7.513	7.481	0.031	3.9	68.16	0	3.05	12.47	0.73	15.59	8	
2001	75	0	79	7.512	7.481	0.031	2.8	59.8	0	3.73	15.24	2.2	19.04	9	
2001	305	0	71	7.507	7.481	0.026	3.3	63.59	0	3.36	13.75	2.11	17.19	10	
2001	210	0	36	7.502	7.481	0.021	3.5	65.54	0	3.27	13.36	1.14	16.7	11	
2001	246	0	20	7.501	7.481	0.02	3.9	68.2	0	3.05	12.48	0.68	15.59	12	
2001	178	0	79	7.498	7.481	0.017	3.4	64.53	0	3.31	13.55	1.69	16.93	13	
2001	214	0	71	7.497	7.481	0.016	3.9	67.88	0	3.04	12.42	1.15	15.52	14	
2001	166	0	27	7.498	7.481	0.016	3.4	64.67	0	3.32	13.58	1.48	16.96	15	
2001	56	0	79	7.496	7.481	0.015	2.8	60.57	0	3.77	15.44	0.93	19.29	16	
2001	54	0	79	7.496	7.481	0.015	2.8	60.04	0	3.74	15.3	1.79	19.12	17	
2001	345	0	53	7.492	7.481	0.011	3.1	62.72	0	3.53	14.44	1.26	18.04	18	
2001	343	0	27	7.492	7.481	0.011	3.1	62.02	0	3.49	14.28	2.38	17.84	19	
2001	213	0	20	7.492	7.481	0.011	3.5	65.5	0	3.26	13.36	1.21	16.69	20	
2002	241	0	79	7.57	7.481	0.089	3.9	66.56	0	2.98	12.18	3.06	15.22	1	
2002	298	0	28	7.559	7.481	0.078	3.3	63.87	0	3.38	13.81	1.68	17.26	2	
2002	253	0	20	7.55	7.481	0.069	3.9	67.72	0	3.03	12.39	1.37	15.49	3	
2002	270	0	17	7.545	7.481	0.064	3.9	66.87	0	2.99	12.24	2.6	15.29	4	
2002	85	0	79	7.531	7.481	0.05	2.8	60.77	0	3.79	15.49	0.6	19.36	5	
2002	173	0	79	7.522	7.481	0.041	3.4	64.5	0	3.31	13.54	1.73	16.92	6	
2002	289	0	71	7.52	7.481	0.039	3.3	63.61	0	3.36	13.76	2.09	17.19	7	
2002	207	0	71	7.519	7.481	0.038	3.5	65.51	0	3.27	13.36	1.18	16.69	8	
2002	102	0	18	7.511	7.481	0.03	2.6	57.26	0	3.84	15.72	3.54	19.64	9	
2002	160	0	71	7.508	7.481	0.027	3.4	64.1	0	3.29	13.46	2.34	16.81	10	
2002	299	0	79	7.507	7.481	0.026	3.3	63.56	0	3.36	13.75	2.16	17.18	11	
2002	252	0	79	7.506	7.481	0.025	3.9	67.37	0	3.01	12.33	1.89	15.4	12	
2002	360	0	79	7.505	7.481	0.023	3.1	61.35	0	3.45	14.12	3.43	17.65	13	
2002	86	0	79	7.504	7.481	0.023	2.8	60.02	0	3.74	15.3	1.82	19.12	14	
2002	240	0	20	7.503	7.481	0.022	3.9	66.98	0	3	12.26	2.46	15.32	15	
2002	118	0	71	7.497	7.481	0.016	2.6	58.7	0	3.94	16.11	1.12	20.13	16	
2002	340	0	79	7.494	7.481	0.013	3.1	61.21	0	3.44	14.09	3.65	17.61	17	
2002	251	0	79	7.494	7.481	0.013	3.9	67.56	0	3.02	12.36	1.61	15.45	18	
2002	353	0	79	7.493	7.481	0.012	3.1	62.38	0	3.51	14.36	1.8	17.95	19	
2002	274	0	71	7.493	7.481	0.012	3.9	67.89	0	3.04	12.42	1.13	15.52	20	
2003	212	0	20	7.625	7.481	0.144	3.5	64.88	0	3.23	13.23	2.13	16.53	1	
2003	32	0	79	7.604	7.481	0.123	3	61.06	0	3.55	14.53	2.72	18.15	2	
2003	79	0	17	7.601	7.481	0.12	2.8	59.43	0	3.7	15.15	2.79	18.93	3	
2003	58	0	79	7.545	7.481	0.064	2.8	59.82	0	3.73	15.25	2.15	19.05	4	
2003	284	0	20	7.544	7.481	0.063	3.3	63.22	0	3.34	13.67	2.68	17.08	5	
2003	265	0	53	7.538	7.481	0.057	3.9	67.93	0	3.04	12.43	1.06	15.53	6	
2003	110	0	71	7.533	7.481	0.052	2.6	57.93	0	3.89	15.9	2.42	19.87	7	
2003	108	0	17	7.531	7.481	0.05	2.6	58.72	0	3.94	16.12	1.08	20.14	8	
2003	213	0	79	7.53	7.481	0.049	3.5	64.87	0	3.23	13.23	2.14	16.53	9	
2003	31	0	20	7.518	7.481	0.037	3	60.84	0	3.54	14.47	3.07	18.08	10	
2003	144	0	79	7.517	7.481	0.036	3.1	62.06	0	3.49	14.29	2.31	17.85	11	
2003	140	0	20	7.517	7.481	0.036	3.1	62.28	0	3.51	14.34	1.96	17.92	12	
2003	168	0	20	7.513	7.481	0.032	3.4	63.93	0	3.28	13.42	2.61	16.77	13	
2003	138	0	17	7.513	7.481	0.032	3.1	62.48	0	3.52	14.38	1.65	17.97	14	
2003	258	0	79	7.511	7.481	0.029	3.9	67.08	0	3	12.28	2.31	15.34	15	
2003	227	0	79	7.509	7.481	0.028	3.9	67.39	0	3.01	12.33	1.85	15.41	16	
2003	143	0	17	7.507	7.481	0.026	3.1	61.8	0	3.48	14.23	2.71	17.78	17	
2003	60	0	71	7.507	7.481	0.026	2.8	59.45	0	3.7	15.15	2.76	18.94	18	
2003	196	0	79	7.505	7.481	0.024	3.5	64.87	0	3.23	13.23	2.14	16.53	19	
2003	349	0	17	7.503	7.481	0.022	3.1	61.52	0	3.46	14.16	3.16	17.7	20	

## Ranked Daily Visibility Change for Otter Creek (Top 20 Days for Each Year)

YEAR	DAY	HR	REC	DV(Total)	DV(BKG)	DELTA DV	f(RH)	% of Modeled Extinction by Species					
								%_SO4	%_NO3	%_OC	%_EC	%_PMC	%_PMF
2001	64	0	146	7.602	7.491	0.111	2.8	59.36	0	3.7	15.13	2.91	18.9
2001	80	0	139	7.575	7.491	0.084	2.8	59.45	0	3.7	15.15	2.75	18.94
2001	167	0	230	7.553	7.491	0.063	3.5	64.52	0	3.22	13.16	2.66	16.44
2001	347	0	230	7.553	7.491	0.062	3.1	61.79	0	3.48	14.23	2.73	17.77
2001	202	0	230	7.544	7.491	0.053	3.7	65.95	0	3.11	12.72	2.32	15.9
2001	127	0	230	7.541	7.491	0.051	3.2	63.19	0	3.44	14.09	1.66	17.61
2001	203	0	139	7.517	7.491	0.026	3.7	66.59	0	3.14	12.85	1.37	16.05
2001	75	0	230	7.512	7.491	0.022	2.8	59.91	0	3.73	15.27	2	19.08
2001	166	0	134	7.511	7.491	0.021	3.5	65.32	0	3.26	13.32	1.45	16.64
2001	247	0	230	7.511	7.491	0.02	4	68.74	0	3	12.26	0.67	15.32
2001	210	0	207	7.508	7.491	0.017	3.7	66.83	0	3.15	12.89	1.01	16.11
2001	246	0	139	7.506	7.491	0.015	4	68.75	0	3	12.27	0.65	15.33
2001	178	0	240	7.506	7.491	0.015	3.5	65.29	0	3.25	13.31	1.5	16.64
2001	214	0	230	7.504	7.491	0.014	4.1	68.99	0	2.94	12.01	1.04	15.01
2001	305	0	207	7.504	7.491	0.013	3.3	64.21	0	3.39	13.89	1.14	17.35
2001	343	0	134	7.503	7.491	0.012	3.1	62.1	0	3.49	14.3	2.23	17.86
2001	72	0	134	7.502	7.491	0.011	2.8	60.51	0	3.77	15.42	1.01	19.27
2001	213	0	139	7.5	7.491	0.01	3.7	66.81	0	3.15	12.89	1.02	16.1
2001	76	0	139	7.499	7.491	0.009	2.8	60.16	0	3.75	15.33	1.58	19.16
2001	56	0	230	7.5	7.491	0.009	2.8	60.6	0	3.78	15.45	0.86	19.3
2002	298	0	248	7.587	7.491	0.096	3.3	63.99	0	3.38	13.84	1.5	17.29
2002	241	0	158	7.561	7.491	0.071	4.1	67.76	0	2.88	11.8	2.82	14.74
2002	270	0	195	7.559	7.491	0.068	4	67.64	0	2.95	12.07	2.26	15.08
2002	253	0	139	7.547	7.491	0.057	4	68.19	0	2.97	12.17	1.46	15.2
2002	207	0	134	7.526	7.491	0.036	3.7	66.55	0	3.14	12.84	1.43	16.04
2002	173	0	255	7.526	7.491	0.036	3.5	65.14	0	3.25	13.28	1.73	16.6
2002	289	0	230	7.518	7.491	0.028	3.3	63.73	0	3.37	13.78	1.88	17.22
2002	102	0	207	7.517	7.491	0.026	2.6	57.47	0	3.86	15.78	3.18	19.71
2002	85	0	230	7.514	7.491	0.023	2.8	60.76	0	3.79	15.49	0.6	19.35
2002	240	0	134	7.512	7.491	0.022	4.1	68.24	0	2.9	11.88	2.13	14.84
2002	160	0	230	7.512	7.491	0.022	3.5	65.01	0	3.24	13.26	1.92	16.57
2002	252	0	253	7.509	7.491	0.019	4	67.96	0	2.96	12.12	1.79	15.15
2002	174	0	134	7.502	7.491	0.011	3.5	65.22	0	3.25	13.3	1.59	16.62
2002	269	0	134	7.5	7.491	0.01	4	68.8	0	3	12.28	0.59	15.34
2002	194	0	139	7.5	7.491	0.009	3.7	66.76	0	3.15	12.88	1.1	16.09
2002	299	0	240	7.498	7.491	0.008	3.3	63.88	0	3.38	13.82	1.65	17.26
2002	251	0	230	7.499	7.491	0.008	4	68.04	0	2.97	12.14	1.66	15.17
2002	195	0	230	7.498	7.491	0.008	3.7	66.65	0	3.14	12.86	1.27	16.06
2002	274	0	230	7.498	7.491	0.007	4	68.51	0	2.99	12.22	0.99	15.27
2002	203	0	139	7.498	7.491	0.007	3.7	66.85	0	3.15	12.9	0.97	16.11
2003	212	0	195	7.616	7.491	0.126	3.7	66.18	0	3.12	12.77	1.98	15.95
2003	32	0	240	7.601	7.491	0.111	3	61.12	0	3.55	14.54	2.62	18.17
2003	79	0	207	7.589	7.491	0.098	2.8	59.65	0	3.72	15.2	2.43	19
2003	284	0	134	7.559	7.491	0.069	3.3	63.1	0	3.34	13.65	2.87	17.05
2003	108	0	207	7.542	7.491	0.051	2.6	58.7	0	3.94	16.11	1.12	20.13
2003	265	0	230	7.533	7.491	0.043	4	68.62	0	2.99	12.24	0.84	15.3
2003	58	0	230	7.531	7.491	0.04	2.8	60.22	0	3.75	15.35	1.5	19.18
2003	138	0	134	7.53	7.491	0.039	3.2	63.52	0	3.46	14.17	1.15	17.7
2003	349	0	139	7.526	7.491	0.035	3.1	61.94	0	3.49	14.26	2.49	17.82
2003	143	0	134	7.525	7.491	0.034	3.2	62.74	0	3.42	13.99	2.36	17.48
2003	140	0	139	7.524	7.491	0.033	3.2	63.14	0	3.44	14.08	1.73	17.6
2003	168	0	207	7.519	7.491	0.029	3.5	64.57	0	3.22	13.17	2.6	16.45
2003	31	0	139	7.519	7.491	0.028	3	60.98	0	3.55	14.51	2.84	18.13
2003	227	0	230	7.516	7.491	0.025	4.1	68.49	0	2.91	11.92	1.77	14.9
2003	213	0	255	7.514	7.491	0.024	3.7	66.73	0	3.15	12.87	1.16	16.08
2003	110	0	230	7.514	7.491	0.023	2.6	58.22	0	3.91	15.98	1.93	19.97
2003	109	0	134	7.513	7.491	0.022	2.6	58.15	0	3.9	15.96	2.02	19.95
2003	78	0	134	7.509	7.491	0.018	2.8	58.93	0	3.67	15.02	3.6	18.77
2003	258	0	230	7.508	7.491	0.017	4	67.71	0	2.95	12.08	2.15	15.1
2003	302	0	138	7.507	7.491	0.016	3.3	64.34	0	3.4	13.91	0.96	17.39

## Ranked Daily Visibility Change for James River Face (Top 20 Days for Each Year)

YEAR	DAY	HR	REC	DV(Total)	DV(BKG)	DELTA DV	f(RH)	% of Modeled Extinction by Species						Ranking
								%_SO4	%_NO3	%_OC	%_EC	%_PMC	%_PMF	
2001	72	0	121	7.547	7.4	0.146	2.7	58.28	0	3.77	15.41	3.3	19.25	1
2001	246	0	92	7.508	7.4	0.107	3.6	65.48	0	3.17	12.98	2.15	16.22	2
2001	201	0	84	7.489	7.4	0.089	3.4	64.69	0	3.32	13.58	1.45	16.97	3
2001	238	0	84	7.473	7.4	0.073	3.7	65.53	0	3.09	12.64	2.94	15.79	4
2001	202	0	133	7.472	7.4	0.072	3.4	64.54	0	3.31	13.55	1.66	16.93	5
2001	345	0	92	7.471	7.4	0.071	3	60.7	0	3.53	14.44	3.29	18.04	6
2001	212	0	128	7.469	7.4	0.069	3.4	64.47	0	3.31	13.53	1.78	16.91	7
2001	120	0	84	7.459	7.4	0.058	2.4	55.69	0	4.05	16.56	3	20.69	8
2001	13	0	84	7.446	7.4	0.046	2.8	59.77	0	3.72	15.24	2.23	19.04	9
2001	213	0	128	7.445	7.4	0.045	3.4	64.5	0	3.31	13.54	1.72	16.92	10
2001	56	0	84	7.444	7.4	0.044	2.6	57.24	0	3.84	15.71	3.57	19.63	11
2001	166	0	129	7.438	7.4	0.038	3.3	63.95	0	3.38	13.83	1.56	17.28	12
2001	209	0	92	7.437	7.4	0.037	3.4	64.64	0	3.32	13.57	1.5	16.96	13
2001	323	0	121	7.436	7.4	0.036	2.8	60.41	0	3.76	15.4	1.19	19.24	14
2001	95	0	121	7.436	7.4	0.036	2.4	56.43	0	4.1	16.78	1.71	20.97	15
2001	347	0	131	7.436	7.4	0.035	3	60.51	0	3.52	14.39	3.59	17.99	16
2001	167	0	92	7.435	7.4	0.035	3.3	63.66	0	3.37	13.77	2	17.2	17
2001	137	0	91	7.434	7.4	0.034	3	61.11	0	3.55	14.54	2.62	18.17	18
2001	80	0	104	7.429	7.4	0.029	2.7	58.35	0	3.77	15.42	3.18	19.27	19
2001	337	0	84	7.428	7.4	0.027	3	60.26	0	3.5	14.34	3.98	17.91	20
2002	207	0	124	7.583	7.4	0.182	3.4	64.04	0	3.29	13.44	2.44	16.8	1
2002	254	0	92	7.55	7.4	0.149	3.6	65.45	0	3.17	12.98	2.19	16.21	2
2002	298	0	130	7.54	7.4	0.139	3.2	62.83	0	3.43	14.01	2.22	17.51	3
2002	244	0	130	7.5	7.4	0.1	3.7	66.02	0	3.11	12.74	2.21	15.91	4
2002	240	0	133	7.496	7.4	0.096	3.7	66.3	0	3.13	12.79	1.8	15.98	5
2002	310	0	92	7.468	7.4	0.067	2.8	59.24	0	3.69	15.1	3.1	18.87	6
2002	253	0	133	7.466	7.4	0.066	3.6	66.16	0	3.21	13.12	1.12	16.39	7
2002	194	0	91	7.465	7.4	0.064	3.4	64.23	0	3.3	13.48	2.14	16.85	8
2002	182	0	92	7.464	7.4	0.064	3.3	63.73	0	3.37	13.78	1.89	17.22	9
2002	32	0	128	7.463	7.4	0.063	2.8	60.01	0	3.74	15.3	1.83	19.11	10
2002	203	0	121	7.458	7.4	0.058	3.4	64.31	0	3.3	13.5	2.02	16.87	11
2002	243	0	124	7.457	7.4	0.057	3.7	65.97	0	3.11	12.73	2.28	15.9	12
2002	303	0	131	7.456	7.4	0.055	3.2	62.51	0	3.41	13.94	2.71	17.42	13
2002	286	0	121	7.451	7.4	0.051	3.2	62.79	0	3.42	14	2.28	17.5	14
2002	251	0	91	7.45	7.4	0.05	3.6	65.28	0	3.16	12.94	2.43	16.17	15
2002	215	0	84	7.448	7.4	0.047	3.7	65.99	0	3.11	12.73	2.26	15.91	16
2002	289	0	128	7.444	7.4	0.044	3.2	63.35	0	3.45	14.13	1.42	17.65	17
2002	122	0	92	7.441	7.4	0.04	3	61.3	0	3.56	14.58	2.32	18.22	18
2002	296	0	128	7.435	7.4	0.035	3.2	62.98	0	3.43	14.05	1.98	17.55	19
2002	302	0	92	7.427	7.4	0.027	3.2	62.49	0	3.41	13.94	2.74	17.42	20
2003	253	0	104	7.617	7.4	0.217	3.6	65.38	0	3.17	12.96	2.29	16.2	1
2003	294	0	130	7.564	7.4	0.164	3.2	62.3	0	3.4	13.89	3.05	17.36	2
2003	254	0	92	7.553	7.4	0.153	3.6	65	0	3.15	12.89	2.86	16.1	3
2003	78	0	104	7.525	7.4	0.124	2.7	58.12	0	3.76	15.36	3.57	19.2	4
2003	307	0	84	7.506	7.4	0.105	2.8	60.08	0	3.74	15.31	1.72	19.14	5
2003	244	0	92	7.493	7.4	0.093	3.7	66.3	0	3.13	12.79	1.8	15.98	6
2003	60	0	92	7.487	7.4	0.087	2.6	57.59	0	3.86	15.81	2.97	19.75	7
2003	252	0	91	7.48	7.4	0.08	3.6	65.52	0	3.18	12.99	2.08	16.23	8
2003	302	0	92	7.472	7.4	0.071	3.2	62.39	0	3.4	13.92	2.9	17.39	9
2003	48	0	121	7.471	7.4	0.071	2.6	58.07	0	3.9	15.94	2.17	19.92	10
2003	261	0	84	7.458	7.4	0.057	3.6	66.14	0	3.21	13.11	1.15	16.38	11
2003	22	0	121	7.457	7.4	0.057	2.8	59.9	0	3.73	15.27	2.02	19.08	12
2003	315	0	128	7.453	7.4	0.053	2.8	60.47	0	3.77	15.41	1.08	19.26	13
2003	101	0	84	7.453	7.4	0.052	2.4	56.22	0	4.09	16.72	2.07	20.89	14
2003	284	0	92	7.451	7.4	0.051	3.2	63.19	0	3.45	14.09	1.65	17.61	15
2003	31	0	106	7.451	7.4	0.05	2.8	58.86	0	3.67	15	3.71	18.75	16
2003	32	0	124	7.447	7.4	0.047	2.8	58.94	0	3.67	15.02	3.59	18.77	17
2003	291	0	84	7.446	7.4	0.046	3.2	62.94	0	3.43	14.04	2.05	17.54	18
2003	308	0	128	7.442	7.4	0.042	2.8	60.42	0	3.76	15.4	1.16	19.24	19
2003	327	0	121	7.441	7.4	0.041	2.8	60.04	0	3.74	15.3	1.79	19.12	20

## Ranked Daily Visibility Change for Brigantine (Top 20 Days for Each Year)

YEAR	DAY	HR	REC	DV(Total)	DV(BKG)	DELTA DV	f(RH)	%_SO4	% of Modeled Extinction by Species					%_PMF	Ranking
									%_NO3	%_OC	%_EC	%_PMC			
2001	52	0	10	7.567	7.438	0.128	2.6	57.97	0	3.89	15.91	2.35	19.88	1	
2001	279	0	9	7.564	7.438	0.126	3.3	63.31	0	3.35	13.69	2.55	17.11	2	
2001	327	0	16	7.557	7.438	0.119	2.9	60.5	0	3.64	14.89	2.37	18.6	3	
2001	125	0	3	7.552	7.438	0.113	3	61.1	0	3.55	14.54	2.65	18.16	4	
2001	266	0	10	7.549	7.438	0.111	3.6	65.32	0	3.17	12.95	2.39	16.18	5	
2001	339	0	5	7.543	7.438	0.105	2.8	59.62	0	3.71	15.2	2.48	18.99	6	
2001	271	0	10	7.543	7.438	0.104	3.6	65.48	0	3.17	12.98	2.15	16.22	7	
2001	258	0	1	7.538	7.438	0.1	3.6	65.29	0	3.16	12.94	2.43	16.17	8	
2001	320	0	2	7.537	7.438	0.099	2.9	60.23	0	3.62	14.82	2.8	18.52	9	
2001	207	0	10	7.537	7.438	0.099	3.4	64.62	0	3.32	13.56	1.55	16.95	10	
2001	277	0	2	7.528	7.438	0.09	3.3	63.26	0	3.34	13.68	2.62	17.09	11	
2001	182	0	2	7.527	7.438	0.089	3.2	62.89	0	3.43	14.03	2.13	17.53	12	
2001	124	0	10	7.522	7.438	0.083	3	61.31	0	3.57	14.58	2.32	18.22	13	
2001	340	0	1	7.516	7.438	0.078	2.8	59.86	0	3.73	15.26	2.09	19.07	14	
2001	8	0	3	7.516	7.438	0.078	2.8	59.82	0	3.73	15.25	2.16	19.05	15	
2001	315	0	1	7.515	7.438	0.077	2.9	60.5	0	3.64	14.89	2.37	18.6	16	
2001	123	0	10	7.512	7.438	0.073	3	61.43	0	3.57	14.61	2.12	18.26	17	
2001	32	0	2	7.503	7.438	0.065	2.8	59.24	0	3.69	15.1	3.11	18.87	18	
2001	278	0	2	7.503	7.438	0.064	3.3	63.3	0	3.35	13.69	2.55	17.11	19	
2001	165	0	3	7.502	7.438	0.064	3.2	62.91	0	3.43	14.03	2.11	17.53	20	
2002	229	0	10	7.579	7.438	0.141	3.7	66.37	0	3.13	12.8	1.7	16	1	
2002	27	0	16	7.53	7.438	0.092	2.8	59.99	0	3.74	15.29	1.88	19.11	2	
2002	28	0	2	7.525	7.438	0.087	2.8	59.17	0	3.69	15.08	3.21	18.85	3	
2002	178	0	16	7.52	7.438	0.081	3.2	62.59	0	3.41	13.96	2.6	17.44	4	
2002	163	0	16	7.516	7.438	0.077	3.2	63.06	0	3.44	14.06	1.87	17.57	5	
2002	337	0	10	7.508	7.438	0.069	2.8	59.84	0	3.73	15.25	2.13	19.06	6	
2002	248	0	2	7.504	7.438	0.066	3.6	65.46	0	3.17	12.98	2.17	16.22	7	
2002	158	0	5	7.505	7.438	0.066	3.2	63	0	3.43	14.05	1.97	17.56	8	
2002	108	0	5	7.505	7.438	0.066	2.6	57.58	0	3.86	15.81	3	19.75	9	
2002	357	0	16	7.497	7.438	0.059	2.8	59.48	0	3.71	15.16	2.71	18.94	10	
2002	218	0	16	7.493	7.438	0.055	3.7	66.31	0	3.13	12.79	1.8	15.98	11	
2002	128	0	14	7.49	7.438	0.051	3	61.61	0	3.58	14.66	1.84	18.32	12	
2002	168	0	2	7.488	7.438	0.05	3.2	63.08	0	3.44	14.07	1.83	17.58	13	
2002	29	0	16	7.489	7.438	0.05	2.8	59.79	0	3.73	15.24	2.21	19.04	14	
2002	226	0	16	7.486	7.438	0.047	3.7	66.1	0	3.12	12.75	2.1	15.93	15	
2002	138	0	1	7.486	7.438	0.047	3	61.51	0	3.58	14.63	2	18.29	16	
2002	83	0	16	7.486	7.438	0.047	2.7	58.98	0	3.81	15.59	2.15	19.48	17	
2002	67	0	2	7.486	7.438	0.047	2.7	59.14	0	3.82	15.63	1.88	19.53	18	
2002	39	0	16	7.486	7.438	0.047	2.6	57.91	0	3.89	15.9	2.45	19.86	19	
2002	342	0	16	7.485	7.438	0.046	2.8	59.51	0	3.71	15.17	2.67	18.95	20	
2003	234	0	16	7.57	7.438	0.132	3.7	66.18	0	3.12	12.77	1.98	15.95	1	
2003	357	0	16	7.552	7.438	0.114	2.8	59.88	0	3.73	15.26	2.05	19.07	2	
2003	235	0	2	7.54	7.438	0.102	3.7	65.77	0	3.1	12.69	2.59	15.85	3	
2003	264	0	2	7.533	7.438	0.094	3.6	64.92	0	3.15	12.87	2.99	16.08	4	
2003	209	0	2	7.526	7.438	0.088	3.4	64.32	0	3.3	13.5	2.01	16.87	5	
2003	182	0	1	7.526	7.438	0.088	3.2	62.84	0	3.43	14.01	2.21	17.51	6	
2003	233	0	16	7.51	7.438	0.071	3.7	66.24	0	3.12	12.78	1.89	15.97	7	
2003	29	0	16	7.509	7.438	0.07	2.8	59.82	0	3.73	15.25	2.15	19.05	8	
2003	208	0	16	7.505	7.438	0.067	3.4	64.29	0	3.3	13.5	2.05	16.86	9	
2003	335	0	2	7.499	7.438	0.06	2.9	60.24	0	3.62	14.83	2.79	18.53	10	
2003	290	0	5	7.489	7.438	0.05	3.3	64.05	0	3.39	13.85	1.41	17.31	11	
2003	107	0	2	7.485	7.438	0.047	2.6	58.48	0	3.92	16.05	1.5	20.06	12	
2003	306	0	3	7.483	7.438	0.044	2.9	60.18	0	3.62	14.81	2.89	18.51	13	
2003	20	0	16	7.482	7.438	0.043	2.8	59.66	0	3.72	15.21	2.41	19	14	
2003	165	0	3	7.478	7.438	0.04	3.2	62.63	0	3.41	13.97	2.54	17.45	15	
2003	293	0	16	7.477	7.438	0.039	3.3	63.56	0	3.36	13.75	2.16	17.18	16	
2003	68	0	5	7.472	7.438	0.034	2.7	58.92	0	3.81	15.57	2.24	19.46	17	
2003	243	0	2	7.471	7.438	0.033	3.7	65.45	0	3.09	12.62	3.07	15.77	18	
2003	238	0	16	7.471	7.438	0.033	3.7	66.25	0	3.12	12.78	1.88	15.97	19	
2003	194	0	2	7.471	7.438	0.033	3.4	64.67	0	3.32	13.57	1.48	16.96	20	

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